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Towards An Integrated Forecasting System For Pelagic Fisheries

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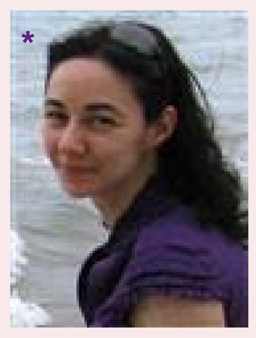


First results of a coupled modelling and forecasting system for pelagic fisheries are presented. The system consists of three model subsystems: POLCOMS-ERSEM provides the physical-biogeochemical environment implemented in the domain of North-West European shelf, Sandeel Population Analysis Model describes the sandeel stocks in the North Sea and Sandeel Larval Analysis Model connects POLCOMS-ERSEM and SPAM by computing the physical-biological interaction. The model system is tested for scientific questions appearing in spatial fish stock management and marine spatial planning, including determination of local- and basin-scale Maximum Sustainable Yield, stock connectivity and source/sink structure. Our simulations indicate that sandeel stocks are currently exploited close to the MSY, but large uncertainty is associated with determining stock MSY due to stock eigen dynamics and climatic variability. Our statistical ensemble simulations indicate that the predictive horizon set by interannual climate variability is 2-6 years, after which only an asymptotic probability distribution of stock properties is predictable.

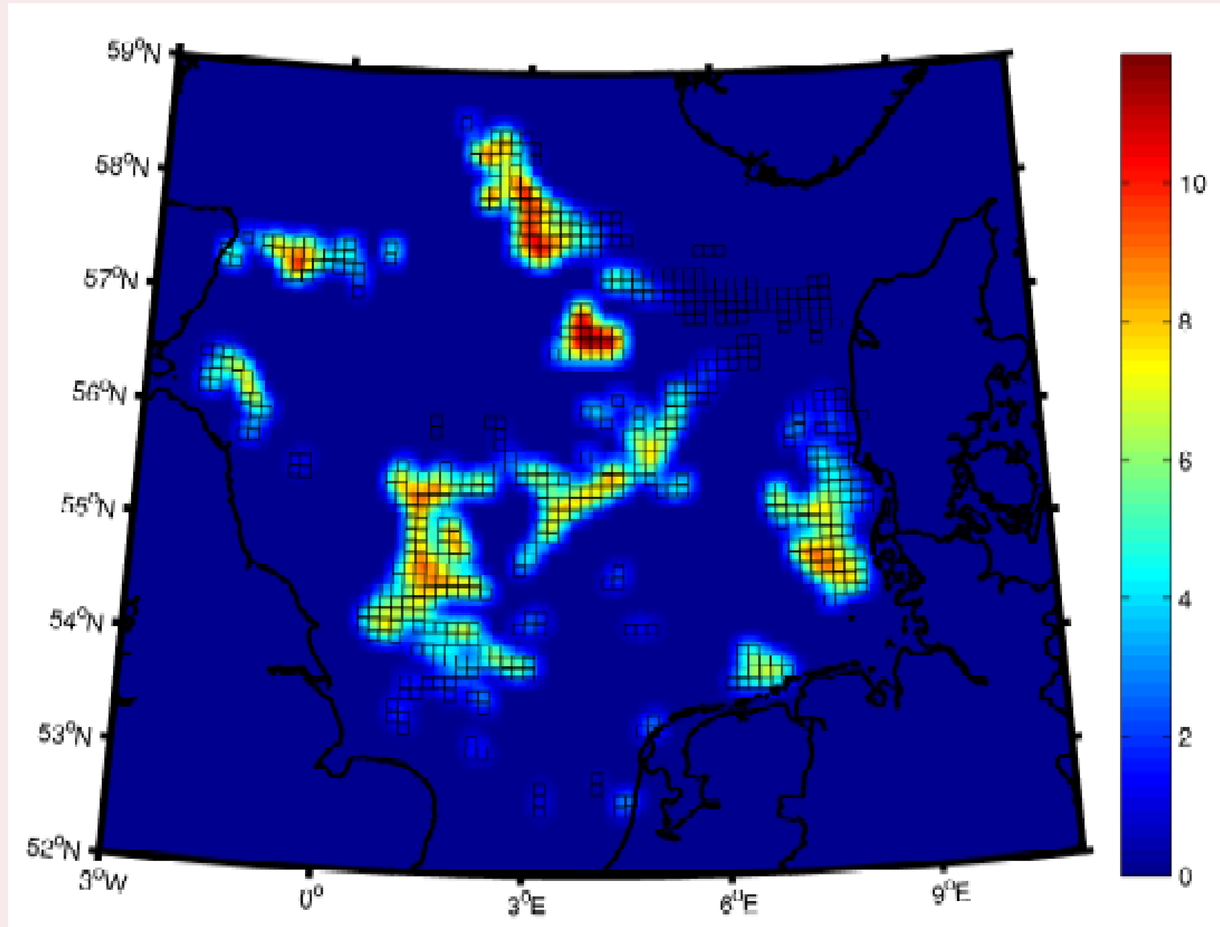


Figure 3. Maximum local fishing pressures for sandeel derived based on expected number of settled offspring for a newly settled juvenile.

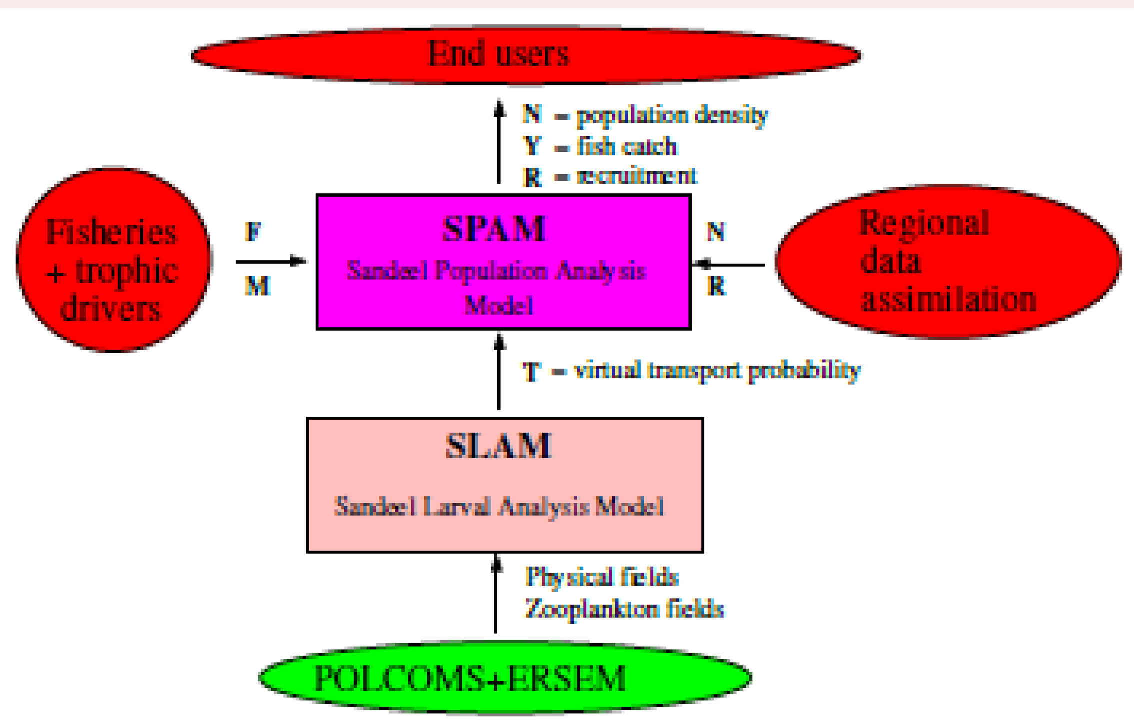
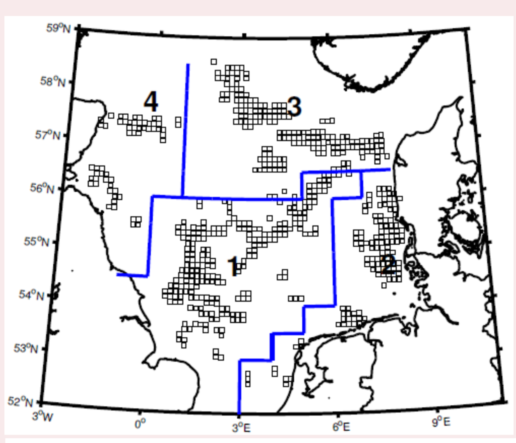


Figure 1. Conceptual diagram of the model system.

Results & Conclusions. Well-defined generic model interfaces are required for a successful and operational model system. Data assimilation is recommended to use to reduce model error. Cost function as index of model skill indicates very good to good fit of predictions to fish stock assessments for biomass (TSB; biomass of age ≥ 1) and recruitment. Local- and basin-scale MSY, stock connectivity and source/sink structure in relation to spatial fish stock management and marine spatial planning are looked into by the coupled forecasting system.

Introduction & Methods. A spatial fish stock forecasting system that can run with flexible levels of data assimilation is presented to provide sandeel population forecasts, assess effects of stock management actions and down-scale regional-scale stock variability. The sandeel life-cycle model consists of hydrodynamic-biogeochemical model, POLCOMS-ERSEM, spatial population model of settled sandeel cohorts, SPAM (Christensen et al., 2009) and individual-based model describing transport and survival probability of sandeel early life-stages, SLAM (Christensen et al., 2008) (Figure 1). SLAM generates spatial transport matrix (*T*^{y}) for each year (*y*) describing habitat connectivity and used as input for SPAM in calculating recruitment (*R*^{y}), abundance (N^y_{ia}) and average length (L^y_{ia}) in each habitat cell (*i*) for each generation with age *a*.



Lines on the map show regional division of sandeel habitat network to areas 1-4 by ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). Small boxes are sandeel habitats resolved on 10 km scale.

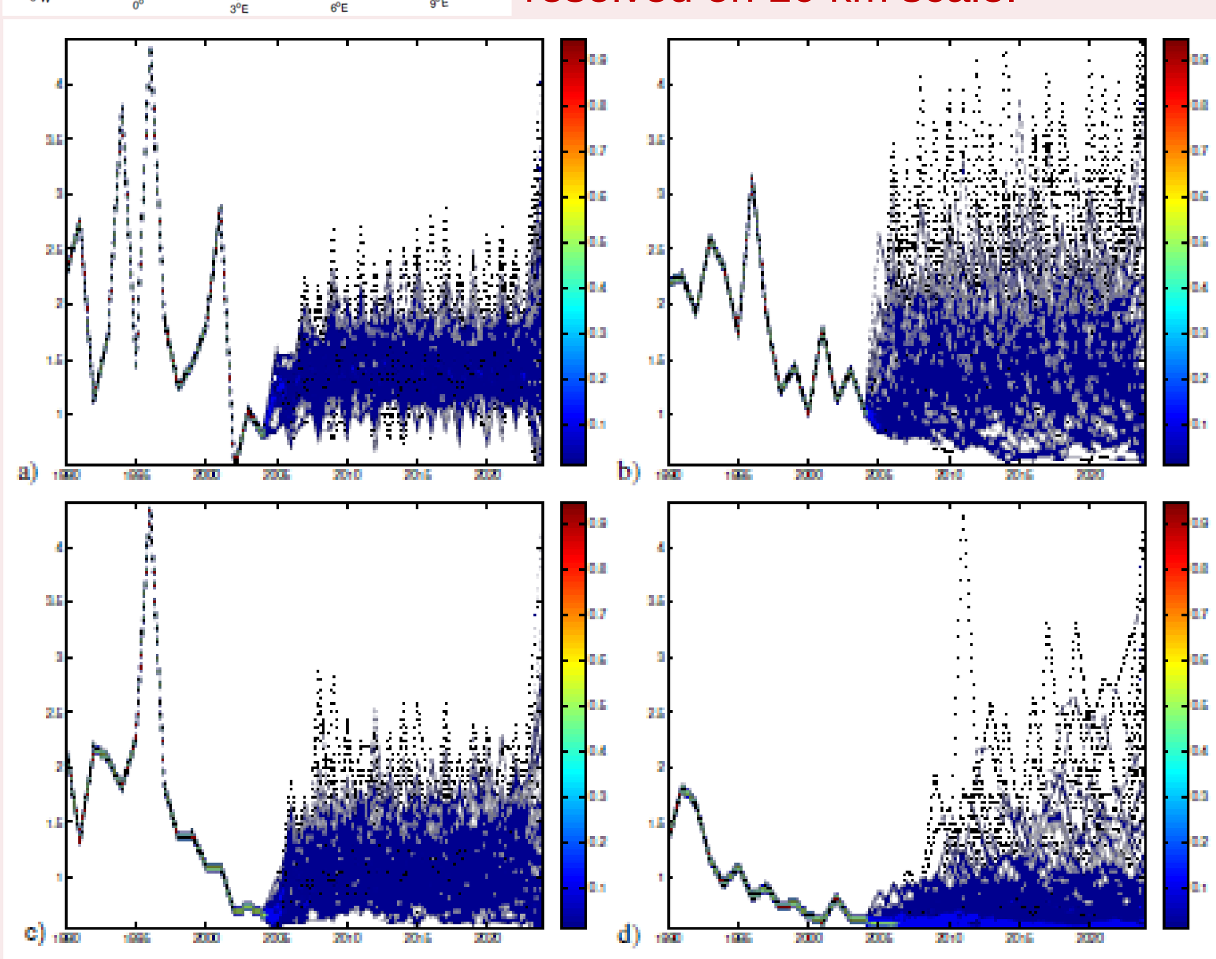


Figure 2a – d. 20 year ensemble forecasts of sandeel TSB with reanalysis runs between 1990-2004 in WGNSSK areas 1-4. Two-year autocorrelation is observed due to population density effect.
a. Area 1. **b.** Area 2. **c.** Area 3. **d.** Area 4.

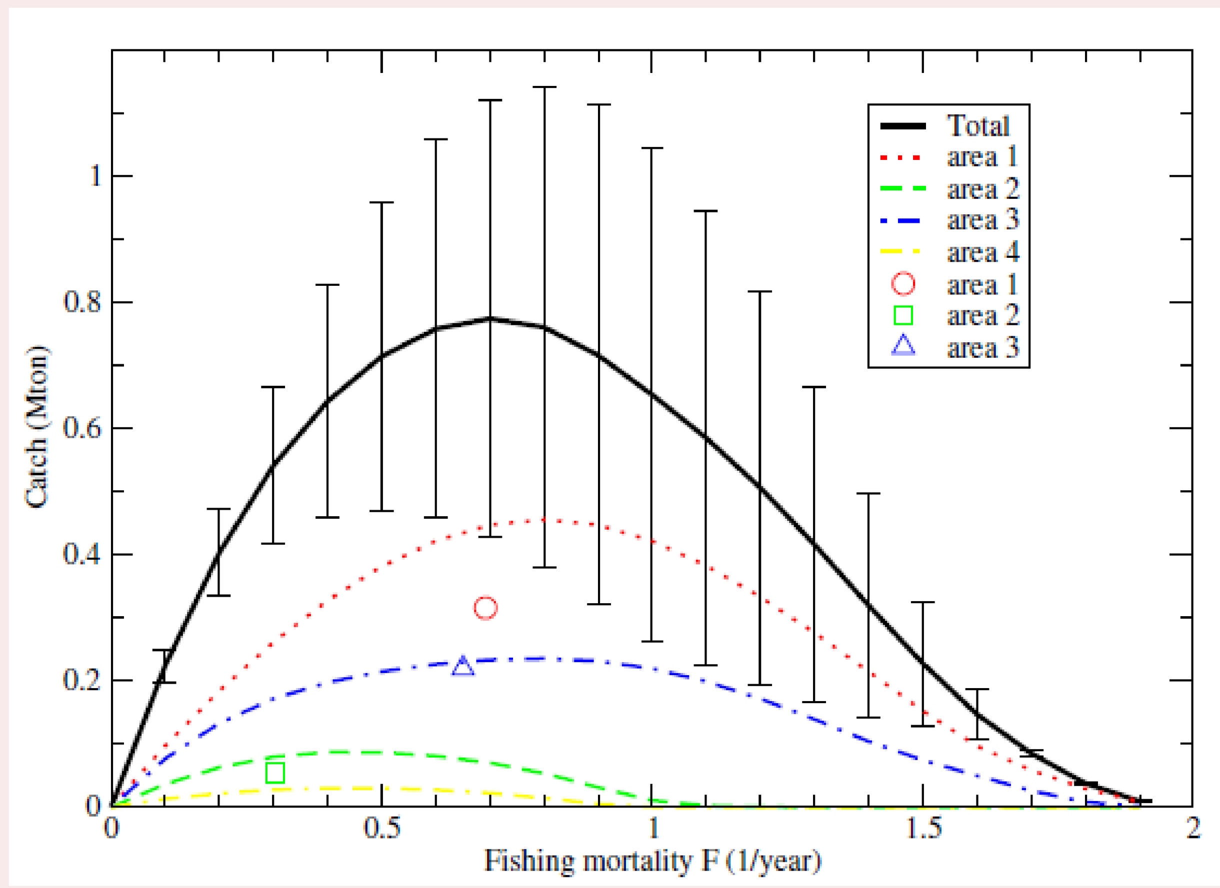


Figure 4. Predicted sandeel catches as function of fishing pressure. Error bars show interannual variability. Symbols are actual historic data.

Simulations indicate that the predictive horizon set by interannual climatic variability is 2-6 years, after which the two-year autocorrelation is masked and only asymptotic probability distributions of stock properties are predictable (Figure 2). Local-scale mapping indicates spatially varying productivity of recruitment sources and sinks, hence, small-scale stock dynamics is dependent on the exchange of larvae between nearby habitats, which affects local fishery vulnerability (Figure 3). Boundary habitats have higher vulnerability than inner habitats due to their higher hydrographic loss of offspring. Analysis of regional yields at different fishing mortalities indicates that harvesting of sandeel is around MSY in WGNSSK areas 1-3 (Figure 4).

Ack.: MEECE MyOcean SUNFISH

References: Christensen et al., 2008. Can. J. Fish. Aquat. Sci. 65: 1498-1511.
Christensen et al., 2009. ICES J. Mar. Sci. 66: 56-63.